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Ancient oak wood-pasture as a habitat for the endangered tree pipit *Anthus trivialis*

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Abstract: Ancient wood-pastures are facing a major decline in several European countries. These habitats are of great importance for biodiversity because of their special, semi-natural character that increases landscape variability and connectivity. In this paper we examine the habitat preferences of the tree pipit *Anthus trivialis* in an ancient oak wood-pasture, the Breite Natural Reserve, central Romania, with the aim of identifying the most significant habitat variables correlated with the presence of this species. In this way, we aim to highlight the need for conservation management of both the species and this particular habitat type, which are both declining across Europe. We found that the number of oaks with a diameter at breast height (d.b.h) > 1.27 m (equating to a circumference of 4 m) was the only variable with significant positive effect on the presence of the tree pipit. Shrub cover had significant negative effect on presence. Tree canopy cover, the clumping tendency of trees and distance from forest had no effect on the presence of this species in the study area. Our results show that the habitat requirements for the maintenance of the tree pipit impose the same active management needs as those for the maintenance of the ancient wood-pasture character of the Breite Natural Reserve, namely the control against hornbeam invasion and ensured viability of new oak sapling generations.

Key words: *Anthus trivialis*; ancient oak wood-pasture; habitat preference; Romania

Introduction

Ancient wood-pastures are particular components of cultural landscapes, and represent a habitat type that is both natural and cultural (Holl & Smith 2002; Manning et al. 2006; McEwan & McCarthy 2008). This habitat is globally threatened mainly due to the expansion of arable farmlands, human settlements, uncontrolled recreational activities, lack of regeneration and abandonment of traditional management (Wilson et al. 1991; Zack et al. 2002; Goldberg et al. 2007). Wood-pastures host a large diversity of organisms, among which invertebrates, especially insects (Holl & Smith 2002; Ranius 2002; Buse et al. 2008; Konvicka et al. 2008; Spitzer et al. 2008), and vertebrates are of great conservation interest (Holl & Smith 2002; Fischer et al. 2005; Manning et al. 2006). Due to its historical and cultural origins, this habitat type contains a large number of old trees, which are key elements for the diversity of woodland bird species (Östlund et al. 1997; Axelsson & Östlund 2001). Besides directly supporting biodiversity, due to the various grades of tree cover, these habitat types with scattered trees play a major role also as ecological corridors between the different forest habitats at a landscape scale (Holl and Smith 2002; Fischer & Lindenmayer 2002; Manning et al. 2006). Their dimensions and structural heterogeneity are important factors contributing to the maintenance of a large diversity of bird species, in comparison with the surrounding habitats (Bellamy et al. 1996; Hansson 1997).

The tree pipit *Anthus trivialis* L., 1758 is a long distance migrant passerine bird species which breeds across most of Europe (Cramp 1998; Hagemeijer & Blair 1997). The typical habitat of this species consists both of open grassland areas, necessary for nesting and feeding, and trees or shrubs used by males as songposts (Loske 1987a; Cramp 1998). The presence of this species is frequently associated with forest edges, both external and internal ones, resulting from forest cuts (Hansson 1983; Nowakowski 2000). We are not aware of studies on the ecology of this species in a similar, wood-pasture habitat. Nowadays this species is sharply declining in the majority of European countries (Sanderson et al. 2006; Gregory et al. 2007). In England for example, a population decline of 82% was recorded between 1981 and 2006 (Baillie et al. 2009). In Romania, the species is not protected by national legislation, partly due to the lack of studies on the ecology of the species. The estimated population size in Romania is, after Heath et al. (2000), 100,000–200,000 individuals and, after Burfield and van Bommel (2004), 600,000–850,000 individuals; the population trend is thought to be stable (Burfield and van Bommel 2004).

We studied the habitat use of the tree pipit during

Table 1. Descriptive statistics for habitat variables at sites where territorial tree pipits were present (n = 23) compared with those where they were absent (n = 24); see methods for description of variables.

	Presence				Absence				
	Average	Min.	Max.	SD	Average	Min.	Max.	SD	*P*
Canopy cover	10.60	2.00	56.00	10.80	9.00	0.00	60.00	17.02	0.70^1
Clumping tendency	0.08	0.00	1.00	0.20	0.20	0.00	1.00	0.40	0.47^2
Shrub cover	11.60	0.00	40.00	9.50	28.80	0.00	90.00	21.50	0.003^2
Forest distance	69.50	50.00	150.00	28.10	59.50	30.00	100.00	18.20	0.15^1
d.b.h.<1.27	2.40	0.00	20.00	4.00	2.80	0.00	23.00	6.00	0.81^1
d.b.h.>1.27	2.60	1.00	7.00	1.30	1.10	0.00	4.00	1.50	0.0006^1

Explanations: ^{1} – t test, ^{2} – Mann-Withney U test.

the breeding season in an ancient oak wood-pasture, the Breite Natural Reserve, central Romania. Our aim was to identify which habitat parameters had a positive or negative influence on the presence of this species. In particular, we investigated whether there were correlations between age-related biometrical characteristics of oaks and the presence of the tree pipit territories.

Material and methods

Study area

The study area was the Breite Natural Reserve, situated on a plateau at an altitude of 504–530 m near Sighişoara. The plateau has an elongated shape in the north-south direction (46°13′05 N, 24°45′18 E to 46°11′03 N, 24°45′14 E) and an area of 133 ha, with an average width of 253.75 m (Median = 240 m, Min = 30 m, Max. = 650 m, SD = 180.58, n = 16).

The Breite Natural Reserve is an ancient oak wood-pasture, where most of the trees are multi-secular oaks (common oak *Quercus robur,* sessile oak *Q. petraea*, gray oak *Q. pedunculiflora* and their hybrids) that have a canopy cover of around 7% of the total area (133 ha) of the open plateau. A few smaller patches where the canopy cover reaches 60% have a more woodland character. Measurements of a random sample of 200 oaks show an average diameter at breast height (d.b.h.) of 1.23 m (Median = 1.32, Min. = 0.46, Max. = 2.32, SD = 0.42).

This culturally transformed habitat type is well represented in this area of Romania, being created in the Middle Ages by the local community in order to increase acorn production and provide sheltered grazing sites for cattle. The size of this wood-pasture is large when compared to other similar habitats studied in Europe, the areas of which average 50 ha (Opdam et al. 1984; Bellamy et al. 1996; Hansson 1997; Goldberg et al. 2007). The thinning of the original forest has led to changes in the humidity regime of the plateau, favouring the penetration of mesophilous meadows with meadow foxtail *Alopecurus pratensis* and great burnet *Sanguisorba officinalis.* A drier climate since the mid-1980s has led to the expansion of the tufted hair grass *Deschampsia cespitosa* on the entire plateau. Shrubs are more scarcely present; the more abundant species are willow *Salix* spp. , dog-rose *Rosa canina* and hawthorn *Crataegus monogyna.*

The plateau is completely surrounded by a mature mixed deciduous forest of sessile oak *Quercus petraea,* hornbeam *Carpinus betulus* and beech *Fagus sylvatica* which is the source for a hornbeam invasion that covers around 17% of the plateau.

Field study

The study was conducted in May 2006, when tree pipit males in this area show greatest territorial activity (Moga unpubl. data). We applied the field methodology elaborated by Bibby et al. (2000), using line transects with unlimited width covering the entire area of the plateau in order to detect all breeding males. Each transect was walked simultaneously by two persons. In the widest part of the plateau (see Study area), we undertook two transects at a distance of 150 m from and parallel to each forest margin. It is assumed that all *A. trivialis* males that exhibited territorial behaviour were detected.

Once a male exhibiting territorial behaviour was identified, we recorded the extreme points (minimum four points) that were used as songposts or to which the male arrived after song flights, to indicate the approximate centre of the territory. Each male was observed only once, for 20–30 minutes. From the centre of the estimated territory, we described the surrounding habitat as 56.5 m radius circle (1 ha), previously described as being the approximate average size of the territory of this species (Loske 1987b; Kumstátová et al. 2004; Burton 2007). When the centre of the polygon was closer than 56.5 m from the forest edge, the radius was adjusted in order to maintain the surface at 1 ha. As control plots, we randomly chose and described in the same fashion 1 ha circles in places within the study area where the males were absent, at minimum distances of 100 m from the margin of the occupied territories. Control plots were selected in a way to cover all microhabitats from the study area. We excluded from the study the recreational area of the reserve (around 2 ha), where the herbaceous vegetation is low and anthropogenic impact is high.

For each 1 ha plot we measured the following variables (Table 1), previously investigated by other authors (Cramp 1988; Loske 1987a; Kumstátová et al. 2004; Burton 2007):

(1) Tree canopy cover (%), i.e. the % of the 1 ha plot over which tree canopies projected, (Cristea et al. 2004), based on measurements of the radius of each tree's canopy.

(2) Clumping tendency. A class variable – 1 for groups of three or more trees with touching canopies; otherwise 0.

(3) Overall shrub cover (%), i.e. the % of the 1 ha plot over which hornbeam, willow and other shrubs projected (Cristea et al. 2004). The hornbeam invasion is compact in most cases; its height varies between 0.50 and 3 m, being higher than 4 m only in isolated areas. The area extent of individual shrubs was measured by their radius or length and width; where the hornbeam invasion was large and more compact, we used GPS measurements to estimate shrub cover.

(4) The distance from the centre of the plot to the forest edge.

The morphology of oaks differs according to their age and dimensions. In order to study the influence of oak morphology on the presence of tree pipits, we determined two further variables:

(5) The number of oaks with d.b.h. < 1.27 m and

(6) The number of oaks with d.b.h > 1.27 m.

We selected 1.27 m d.b.h. (which equates to a median circumference of 4 m) because a key morphological trait in which we were interested – canopy destruction – differed significantly above and below this threshold: for a randomly selected sample of 100 oaks with d.b.h < 1.27 m, canopy destruction averaged 11.36%, (Median = 5.00, Min = 0.00, Max = 98.00, SD = 16.58), whereas a sample of 100 oaks with d.b.h. > 1.27 m had a mean canopy destruction of 40.30% (Median = 32.50, Min = 5.00, Max = 100, SD = 24.54) (Mann-Whitney *U* test, $P < 0.01$). Canopy destruction was defined as the estimated (%) of dead branches in the canopy. Canopy destruction was estimated by two people, and from their individual observations we built up the average values used in the analysis. The 100 oaks with d.b.h. < 1.27 m had an average d.b.h. of 0.86 m (Median = 0.82, Min = 0.46, Max = 1.56, SD = 0.20) while the oaks with d.b.h. > 1.27 averages 1.60 m (Median = 1.56, Min = 1.30, Max = 2.32, SD = 0.20), a difference with statistical significance ($t = -25.63$, df = 198, $P = 0.00$). The average number of oaks with d.b.h. < 1.27 m / sample is 2.65 (Median = 1.00, Min. = 0.00, Max. = 23, SD = 5.11), while for oaks with d.b.h > 1.27 m / sample is 1.89 (Median = 2.00, Min. = 0.00, Max. = 7.00, SD = 1.65); a difference without statistical significance (Mann-Whitney *U* test, $Z = -1.25$, $P < 0.21$), meaning that the proportion of the two oak categories in the analysed samples is equilibrated.

We chose to test these two variables, first, because the scientific literature highlights the importance of large, mature trees for territorial tree pipits to use as song posts (Loske 1987a; Kumstátová et al. 2004; Burton 2007); and second, because measurements of oaks made for the Breite Management Plan indicated that old oaks had more dead branches in their canopies, and we observed that tree pipits frequently landed on these branches after songflights.

In open parts of the study area, which are not covered by shrubs or trees, the herbaceous vegetation is dominated by tufted hair grass (*Deschampsia cespitosa*) with a maximum height of 0.7–0.9 m during the tree pipit's breeding season and with a ground cover of 100% (no visible bare soil). Due to its uniformity, this vegetation level was not considered in the study, though this high cover is generally recognized as optimal.

Data analysis

As there was a strong positive correlation between clumping tendency and the number of oaks with d.b.h. < 1.27 m ($r = 0.77$, $P < 0.01$) we only used clumping tendency in the statistical analysis.

We used binary logistic regression analysis to explore the relationship between the presence (1) / absence (0) of *A. trivialis* and the habitat variables. A best fit model was chosen using a backward selection procedure (Crawley 1993) and this then evaluated using Kappa statistics (Fielding & Bell 1997). This statistic was used to test the extent to which sites were correctly classified by the model compared to that expected by chance. Data are presented in a confusion matrix – classification table (Table 2). The descriptive analysis was done with parametric *t* test and the non-parametric Mann-Whitney *U* test. Normality was tested previously with the Levene test. The statistical analyzes were performed with SPSS 17.

Table 2. Confusion matrix – Classification table used to evaluate the predictive accuracy of the logistic regression. The model correctly predicts 85.1% of the cases.

Observed	Predicted		
	Anthus		Correct Percentage
	Absent	Present	
Anthus trivialis			
Absent	21	3	87.5
Present	4	19	82.6
Overall percentage			85.1

Results and discussion

In total, 23 territories were recorded across the 133 ha of the plateau, a density of 0.17 territories / ha. Habitat variables were recorded at these and 24 control sites (Table 1). The results of the logistic regression analysis showed that *A. trivialis* was more likely to be present in areas with oak trees with a d.b.h. > 1.27 m (β [± 1SE] = 1.593 [0.52], Wald = 9.116, $P = 0.003$). In contrast, presence of *A. trivialis* was negatively affected by shrub cover (β [± 1SE] = 0.147 [0.047], Wald = 9.676, $P = 0.002$). The two variables explained 69% of the variation of the presence of *A. trivialis* (estimated using Nagelkerke R^2). The final model correctly classified the presence or absence of *A. trivialis* territories in 85.1% of sites (Table 2). The value of Kappa was 0.70, suggesting that the model can be considered satisfactory.

We recorded a density of 0.17 territories / ha. Loske (1985), in a study conducted in Middle Westphalia (Germany), recorded a density of 0.47 males / ha in a similar habitat with scattered oaks. The difference may be explained by the difference in microhabitats (i.e., shrub cover). On the other hand, in our study we used results from one season only: as population densities may fluctuate in time, further studies are needed to document the population fluctuation and density.

In our study the number of trees with d.b.h. > 1.27 m was the only variable that had a significant positive influence on the presence of tree pipit males. Other studies (Loske 1987a; Kumstátová et al. 2004; Burton 2007) also highlight the importance of tall, mature trees in the territory that can be used as songposts. A prominent songpost, used at the start and end of songflights, can benefit song performance and thus is an important attribute for attracting females into the territory (Burton 2007; Petrusková et al. 2008). Oaks with dry branches in their canopy also offer good visibility over males' territories, an important criterion during territory selection (Kumstátová et al. 2004).

Shrub cover negatively influenced tree pipit presence. Loske (1987a) previously showed that the habitats preferred by territorial tree pipits have low shrub cover, usually less than 30%. Dense shrub cover reduces the extensive ground cover necessary for the nesting and feeding of this species (Loske 1987a; Cramp 1988; Burton 2007), while it also affects the visibility over the territory (Kumstátová et al. 2004).

We found no correlation between canopy cover and the presence of the tree pipit. The maximum canopy cover in the study area is 60%, which is between the normal, even optimal limits recorded in other studies. Loske (1987a) showed that the optimal canopy cover for the presence of this species is below 60%, although it can tolerate cover of up to 80%, similar results being noted also by Kumstátová et al. (2004). Even so, in these studies the species was also recorded at sites with much lower canopy cover (Cramp 1988; Loske 1985). Completely open areas without trees were not occupied, a similar finding to previous studies on the ecology of this species (Cramp 1988; Loske 1985, 1987a; Kumstátová et al. 2004; Burton 2007). An exception to this is the study of Kumstátová et al. (2004) in which tree pipit territories were found on steep slopes lacking trees and shrubs, the slope acting as a songpost and look-out.

The clumping tendency of trees had no influence on the presence of tree pipit males. Due to low tree cover, there is high visibility over territories on the plateau, this being an important criterion during the territory selection of males (Kumstátová et al. 2004). Other studies highlight the preference of the tree pipit for sparsely, scattered trees (Cramp 1988; Loske 1985, 1987a).

Although we did not find a significant correlation with distance from the forest edge, previous studies suggest a preference of this species for the transition (ecotone) zone between grassland and forest (Loske 1987a; Cramp 1988; Hansson 1983; Nowakowski 2000). It is possible that the relatively uniform distribution of males is a result of the elongated shape of the plateau, its small width and of the uniform distribution of key habitat structural elements (high herbaceous vegetation and mature trees that supply efficient song-posts). Burton (2007) showed that in young forest stands, where planted trees were less than 0.8 m high, territories were restricted to the forest edge as this provided the only available songposts.

Our study has shown that the key structural element of the Breite Natural Reserve, i.e., the morphology of the multi-secular oaks, is of major importance for the maintenance of *Anthus trivialis* in the area. Ancient wood-pastures are still maintained in Eastern Europe, particularly in central Romania, though the Breite and other similar habitats are threatened by Hornbeam invasion and the natural succession towards forest. Given the negative correlation between tree pipit presence and shrub cover, this would lead to a degradation of the site's conservation value and its importance as habitat for the species. Another major threatening factor is the lack of oak regeneration. Active management is thus needed to reduce and control the Hornbeam invasion into the wood-pasture and secure the presence of younger oaks. These are general requirements for all similar habitats situated in Saxon Transylvania, which, together with the maintenance of traditional land-use practices (moderate grazing, mowing, cuttings and plantings), would ensure oak regeneration, impede the natural succession towards forest and secure the conservation of tree pipit populations in this old cultural habitat.

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